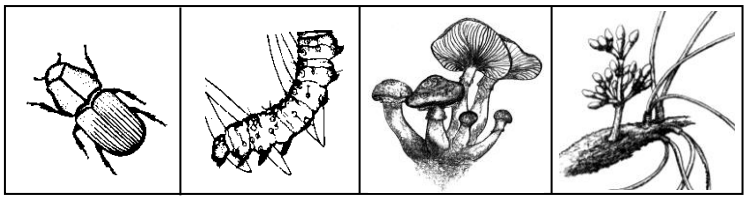
Forest Health Protection



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Reducing Individual Tree Susceptibility to Mountain Pine Beetle by Pruning and Daylighting; a Case Study at Mink Peak, Superior Ranger District, Lolo National Forest, Montana

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Whitebark pine forests have been declining across the Northern Rockies largely due to impacts from large-scale mountain pine beetle, *Dendroctonus ponderosae* Hopkins (MPB) outbreaks, white pine blister rust (*Cronartium ribicola* Fisch) and fire-exclusion practices. Silvicultural treatments, including prescribed fire and thinning, have been used to successfully restore whitebark pine stands (Kean and Parsons 2010a, 2010b). Further work (daylighting) is being conducted to identify and evaluate less expensive methods to restore larger landscapes containing whitebark pine (Keane 2011). Waring and Six (2005) suggest that because of potential unforeseen consequences following whitebark pine restoration, bark beetles and climatic conditions before should be monitored during and after treatments to help determine if mitigation measure are needed.

The objective of this study was to evaluate pruning and daylighting treatments on individual whitebark pine trees to reduce mountain pine beetle-caused tree mortality. The project was conducted in whitebark pine stands that are part of a larger Rocky Mountain Research Station project examining daylighting techniques for restoring whitebark pine ecosystems (Keane 2011).

Methods

Mink Peak is located on the Superior Ranger District on the Lolo National Forest. The stands at Mink Peak are relatively young, whitebark pine stands with approximately 20-25 mature whitebark pine trees per acre intermixed with lodgepole pine, subalpine fir and mountain hemlock. The site is mostly north-facing towards Lost Lake with gentle slopes. In 2012, MPB was not active in the treatment stand but could be found killing several groups of 5 to 25 lodgepole pine trees within ½ mile in Montana. Significant MPB activity was also occurring within several miles of Mink Peak across the ridge into Idaho.

In August of 2012, USDA Forest Service Crews (Superior Ranger District) implemented daylighting treatments on approximately 27 acres of whitebark pine stands at Mink Peak in accordance with RMRS Daylighting Study Plan (Keane 2011). Competing non-whitebark pine trees were cut from within 15 feet of all whitebark pine trees that were over 5 feet tall, had a live top and a generally good growth form.

On September 17-18, 2012, 60-whitebark pine trees ranging between 7 and 20 inches d.b.h, that appeared to be free of blister rust bole cankers, were selected as treatment trees (Figures 1 & 2). Diameters of selected trees ranged between 7 and 20 inches. We attempted to select the largest trees in the stands; only a few smaller 7 inch diameter trees were selected in each treatment category. The daylighting treatment resulted in basal areas ranging between 10 to 70 square feet per acre (average-34 square feet per acre) – stocking densities which have been shown to be effective at limiting mountain pine beetle-caused mortality in other pine species. In addition, we extended the daylighting treatment to remove large trees an additional three feet or 18 feet from treatment trees.

Figures 1 & 2. Pruned Whitebark Pine Trees at Mink Peak, Lolo National Forest.

Additionally, we assigned a pruning treatment to every other selected daylighted whitebark pine tree (30 trees). The pruning treatment consisted of removing all branches from the lower 12 feet of the bole or ½ the live crown, whichever was less. Pruning removed the effect of branch shading on the bole. In adjacent natural stands, an additional 30 control trees (over 7 inches in diameter) that had not been daylighted or pruned were selected and tagged. Diameter at breast height was taken for treatment and control trees. On July 15, 2013, mountain pine beetle lures (Synergy Semiochemicals) attached to wooden stakes, were placed approximately 10 feet from each treatment and control tree. Lures were used in the study to insure that adequate beetle pressure was present and evenly distributed throughout the project area.

Fig. 3. Control Area.

Fig. 4. MPB Attacks on Control Tree.

On August 5, 2013, the study site was visited to evaluate the effectiveness of the lures in drawing in MPB. MPB appeared to be actively attacking many of the treatment and control trees. The decision was made by the District (with input from FHP) to attempt to reduce the amount of mountain pine beetle-caused tree mortality by 1) removing lures on August 5, 2) felling and slashing beetle infested trees in the in treatment and control areas in September 2013, 3) applying the anti-aggregant verbenone at a rate of 30 pouches per acre on a grid across the treatment and control areas in June of 2014.

Following beetle flight in September of 2013 and 2014, all trees were evaluated for MPB activity (mass-attacked, strip attacked, unsuccessfully attacked or no attacks). Trees were recorded as mass-attacked by MBP when more than ¾ of the circumference of the tree had copious amounts of boring dust around it and other evidence of beetle attacks; unsuccessful attacks were evidenced by minor amounts of boring dust and/or pitch tubes; strip attacks were evidenced by attacks confined to less than ¾ of the circumference of the tree bole with boring dust and other evidence of beetle attacks.

In addition in fall of 2013, we established a fixed plot (35'radius) around each treatment and control tree to gain additional information regarding mountain pine beetle activity in the study area. Mountain pine beetle activity (mass, strip, unsuccessful and not attack) was recorded for all pine trees in fixed plots. Secondary insect attacks were also recorded for all treatment and control trees and was determined by the presence of frass, entry holes and peeling back bark to examine galleries.

Information was collected on white pine blister rust in September 2013 and July 2014, and included height to lowest canker, number of lethal and branch cankers in each tree and their location in the crown (bottom third, middle third, top third). A lethal canker was defined as a bole canker or a branch canker within 6 inches of the bole. Height to lowest live branch was also recorded for all trees.

Statistical Analysis:
Analysis was done on percent survival (i.e. not masses attacked and killed by MPB) and percent not attacked, either successfully or unsuccessfully, by MPB. Frequency counts for each analysis variable were compared for each treatment to the control in contingency tables using Fisher's Exact Test.

Results
Mountain pine beetle activity was common in the plots surrounding treatment trees following baiting of the area with 76.7% of the plots surrounding Control, and Daylight and Prune trees having MPB attacks; and 73.3% of the plots surrounding Daylight trees having MPB attacks. The Control trees had a majority of trees attacked by MPB, successfully or unsuccessfully, in the two years following baiting with 63.3% of the trees MPB attacked and 36.7% of the trees free of MPB attack. Two-years following treatment and baiting, the Daylight (66.7%, P = 0.02) and the Daylight and Prune (80%, P = 0.001) both had significantly more trees not attacked by MPB when compared to the Control (36.7%) (Table 1).

Table 1. Efficacy of daylighting and pruning treatments for reducing mountain pine beetle attacks on whitebark pine trees at Mink Peak, Lolo National Forest, Montana, USA.

Treatment	Tested (n)	Attacked	Not Attacked	Percent Success*	P value[1]
Control	30	19	11	36.7%	---
Daylight	30	10	20	66.7%	0.02
Daylight and Prune	30	6	24	80.0%	0.001

*Success equals no mountain pine beetle attacks, successful or not, recorded summer 2013 and 2014
[1]P value for rejecting binomial test H0 that treatment success was equal to Control success

A total of 11 trees across the whole experiment were killed by MPB, with seven (63%) of those in the Control trees. When compared with the mortality found in the Control trees (76.7% survival), the Daylight trees had a higher but not statistically significant survival rate (90%, P = 0.15), while the Daylight and Prune had a significantly greater survival rate (96.7%, P = 0.05)(Table 2).

Table 2. Efficacy of daylighting and pruning treatments on preventing mountain pine beetle-caused whitebark pine mortality at Mink Peak, Lolo National Forest, Montana, USA.

Treatment	Tested (n)	Dead	Alive	Percent Success*	P value[1]
Control	30	7	23	76.7%	---
Daylight	30	3	27	90.0%	0.15
Daylight and Prune	30	1	29	96.7%	0.05

*Success equals alive and not mass attacked as of September 2014
[1]P value for rejecting binomial test H0 that treatment success was equal to Control success

In 2013-2014, four trees had limited attacks from either a *Pityogenes* or *Pityopthorus* species (collectively referred to as "Pitys"; two in the daylighted only treatment and two in the daylighted and pruned treatment. Little to no tree mortality is expected from the attacks by these secondary insects alone. Two of the trees attacked by Pitys were also attacked by mountain pine beetle.

White Pine Blister Rust

Average tree height is similar across all treatments, and is 35.9, 36.8, and 36.7 feet, for control, daylight, and daylight and pruned trees, respectively. Average height to lowest live branch, after treatment, for control, daylight, and daylight and pruned trees is 3.7 feet , 4.0 feet, and 12.5 feet, respectively (Fig. 5). Obviously, pruning raised the height of the lowest live branch. Average height to lowest canker, after treatment, for control, daylight, and daylight and pruned trees is 12.1, 12.5, and 17.1 feet, respectively (Fig. 6), indicating pruning raised the height of the lowest canker. Tree infection rates from white pine blister rust after treatment are 73% for control, 73% for daylight and prune treatment, and 76% for daylight treatment (Tables 1 and 2). Treatment appeared to have no effect on tree infection rates.

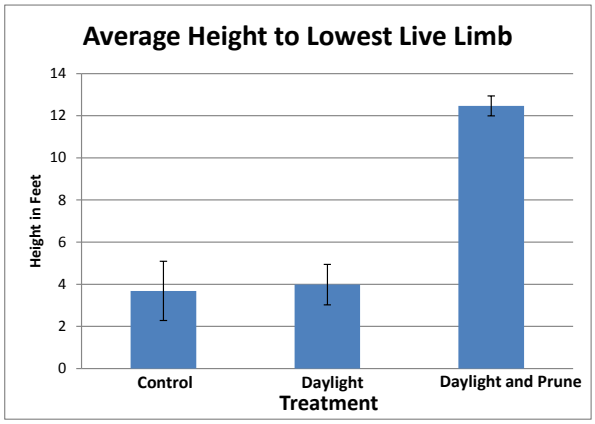

Figure 5. Average height of the lowest live limb in all three treatments (95% conf. int.)

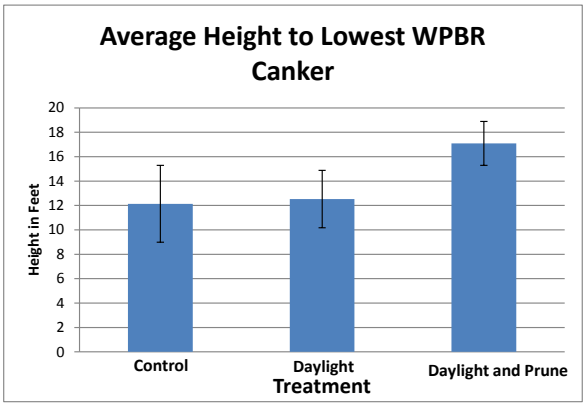

Figure 6. Average height to lowest white pine blister rust canker in all three treatments (95% conf. int.).

Over 37% of non-pruned trees (control and daylight only) have their lowest canker at 13 feet or higher, which is above the average pruning height of 12.5 feet. Additionally, almost 53% of non-pruned trees have cankers in the top 2/3 of their crowns (Table 3), which is approximately 14.9 feet and higher, well above pruning height. Furthermore, lethal cankers were recorded in seven pruned trees (Table 4) and in six non-pruned trees above pruning height (in top 2/3 of crowns, Table 3).

Table 3. Total number of cankers and crown placement in non-pruned trees. Lethal cankers were bole cankers or cankers within 6 inches of the bole, while branch cankers were greater than 6 inches from the bole.

Treatment (# trees)	Total # lethal cankers lower 1/3 crown	Total # branch cankers lower 1/3 crown	Total # lethal cankers middle 1/3 crown	Total # branch cankers middle 1/3 crown	Total # lethal cankers top 1/3 crown	Total # branch cankers top 1/3 crown	Total # trees with cankers (% infection rate)
Control (n=30)	7 (4 trees)	38 (17 trees)	3 (2 trees)	27 (12 trees)	2 (2 trees)	7 (6 trees)	22 (73%)
Daylight (n=29)	3 (2 trees)	23 (15 trees)	2 (2 trees)	25 (14 trees)	0	9 (3 trees)	22 (76%)

Table 4. Total number of cankers and crown placement in pruned trees. Lethal cankers were bole cankers or cankers within 6 inches of the bole, while branch cankers were greater than 6 inches from the bole.

Treatment (# trees)	Total # lethal cankers lower 1/3 crown	Total # branch cankers lower 1/3 crown	Total # lethal cankers middle 1/3 crown	Total # branch cankers middle 1/3 crown	Total # lethal cankers top 1/3 crown	Total # branch cankers top 1/3 crown	Total # trees with cankers (% infection rate)
Daylight and Prune (n=30)	5 (4 trees)	15 (11 trees)	6 (3 trees)	10 (10 trees)	0	3 (3 trees)	22 (73%)

Discussion

The results of this study suggest that pruned and daylighted whitebark pine trees had less mountain-pine beetle-caused tree mortality than either daylighted only and no treatment (controls). We also found a limited amount of secondary insect attacks on boles of pruned and daylighted trees. However, half of these were found in association with mountain pine beetle attacks which is common for *Pityogenes* and *Pityopthorus* species. Additional tree mortality is not expected to occur from Pity attacks alone. The one tree in the pruned treatment that was mass attacked by MPB was also attacked by Pitys.

Although pruning is labor intensive, it may be an important aspect of providing additional protection to daylighting treatments to reduce mountain pine beetle-caused tree mortality. Pruning trees allows for more sunlight on boles and increased wind and beetle-pheromone dispersion around individual trees and on a stand basis. Bark beetles preferentially seek out densely stocked forests where pheromone communication and optimal temperature and humidity regimes exist for tree selection, initiation of attack and brood survival (Fettig and Hilszczanski 2015).

Even though 20% of pruned daylighted trees were attacked by beetles, only 3% of trees were killed by the attacks. MPB initially attacked both treatment and control trees, but the daylighting and pruning treatments had fewer trees killed by MPB.

Pruning to lift the crown heights is an effective management tool for controlling white pine blister rust in young western white pine, especially if done when the trees are 15 to 20 years of age (Schwandt and Marsden 2002, Schnepf and Schwandt 2006). White pine blister rust cankers in western white pine generally occur in the lower crowns, making pruning a very effective management tool in this tree species. Conversely, cankers in whitebark pine are not usually concentrated in the lower crown, but generally occur throughout the crowns (Goheen et al. 2002), indicating pruning will be much less effective at controlling white pine blister rust in this species.

Data regarding the location of white pine blister rust cankers in the crowns of white bark pine in this study corroborate with other studies. Cankers are located throughout the crown, with nearly 53% of the non-pruned trees having cankers in the top 2/3 of their crowns, approximately 14.9 feet and higher. The majority of non-pruned trees have cankers well above pruning height indicating pruning will likely not be an effective control treatment for white pine blister rust in whitebark pine at this site. It remains to be seen if pruning and/or daylight treatments affect future white pine blister rust infection and mortality rates.

A one-time pruning for controlling attacks by mountain pine beetles may be as cost effective (approximately $300-500/acre) as applying suppression treatments such as verbenone and carbaryl over multiple years ($420-$630) for 2 or 3 years respectively of verbenone applications. Silvicultural treatments such as daylighting and pruning may be perceived in a more positive light by the public then the use of pesticides especially in high-elevation forests.

Additional investigations at other locations would be beneficial to confirm if the results seen in this study occur across multiple settings and over time.

Future Work

In 2015 following beetle flight, mountain pine beetle and secondary insect damage and tree survival will be recorded for all treatment and control trees. We expect that the daylighting treatments will provide more protection over time by allowing trees improved access to water and nutrients therefore improving individual tree vigor.

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